NASA Facts

National Aeronautics and Space Administration
Washington, D.C. 20546
(202) 358-1600

For Release
FACT SHEET **September 26, 2006**

FUNDAMENTAL AERONAUTICS PROGRAM

The Fundamental Aeronautics program supports state-of-the-art research in tools and technologies that enable the design of vehicles that fly through any atmosphere at any speed. In particular, physics-based, multidisciplinary design, analysis, and optimization (MDAO) tools will make it possible to evaluate radically new vehicle designs and to assess, with known uncertainties, the potential impact of innovative technologies and concepts on the overall vehicle performance and value. The development of such tools requires a firm commitment to the pursuit of long-term, cutting-edge, integrated research across the core disciplines of Aeronautics. In addition to these system-level goals, advanced component technologies are being developed to realize the revolutionary improvements in noise, emissions, and performance that are required to sustain a viable future air transportation system. The Fundamental Aeronautics program also helps advance the Agency's human and robotic exploration missions by creating tools that support the development of planetary atmospheric entry vehicles and that facilitate access to space. The Fundamental Aeronautics program is comprised of four projects:

Fixed Wing: This project addresses the requirement that future transport aircraft need to be quieter and cleaner to meet demanding constraints in noise and emissions. At the same time, these aircraft must meet challenging performance requirements to make them economically viable alternatives to the existing fleet. Foundational research in core disciplines will be integrated to enable significant advances in propulsion-power systems, vehicle systems integration and analysis, airframe systems, and systems for experimental validation. Validated, physics-based MDAO capabilities will enable predictive design of a wide class of air vehicles that will meet the future performance challenges for both civilian and military applications.

Rotary Wing: This project focuses on removing the technical barriers that constrain rotorcraft from reaching widespread use in civil aviation. These barriers include range, speed, payload capacity, fuel efficiency, and environmental acceptance (noise in particular). Foundational research in core disciplines will be integrated to enable significant advances in propulsion-aeromechanics integration, integrated vehicle management systems, integrated rotorcraft design, and innovative experimental methodologies. Validated, physics-based MDAO tools will enable predictive design of advanced capability rotorcraft that meet noise and performance challenges.

Supersonics: The Supersonics project has two basic objectives. The first one is the elimination of the efficiency, environmental and performance barriers to practical supersonic cruise in the Earth's atmosphere. The other is to address the critical issue of supersonic deceleration to enable safe, precision planetary entry, descent, and landing of human and large scientific missions in any atmosphere. Foundational research in core disciplines will be integrated to enable significant advances in aircraft systems integration and analysis, airframe systems, propulsion-power systems, and integrated system-level experimental validation. Validated, physics-based MDAO capabilities will enable system-level design of supersonic vehicles that will meet the emission, noise, sonic boom, and performance challenges of the future. In addition, advanced analytical capabilities will enable lightweight concepts for precise, controllable supersonic descent through planetary atmospheres.

Hypersonics: All access to space, either suborbital or in Earth orbit, and all entry from space through any planetary atmosphere, requires hypersonic flight. In order to continue to advance our capabilities for flight in these regimes, improved understanding of hypersonic phenomena is needed. Improved technologies to withstand and take advantage of the high temperature environment are also required. Foundational research will be conducted to enable significant advances in high-speed aerodynamics, very high temperature materials and structures, and robust flight controls. Validated physics-based MDAO capabilities will reduce uncertainties and risk, increase performance, and enable new vehicle concepts. Furthermore, our increased knowledge of hypersonic systems will pave the way for new vehicle architectures to increase the reliability of launch and improve the performance of entry vehicles.

Fundamental Aeronautics Program's Recent Accomplishments

Fixed Wing Project

- Tested two Blended Wing Body (BWB) models to investigate the potential of this revolutionary aircraft configuration to significantly reduce noise and emissions while improving overall performance. A BWB 8.5 percent model was tested in the Langley Research Center full-scale tunnel and a two-percent model was tested in the National Transonic Facility to characterize the aerodynamic and control characteristics in preparation for flight tests at Dryden in early 2007. This work supports X-48B flight test opportunities planned in FY07.
- Completed the design of geared turbofan components in collaboration with Pratt & Whitney. Studies conducted by NASA and Pratt & Whitney identified a low fan-pressure-ratio geared turbofan design with a lightweight Variable Area Fan Nozzle as an attractive approach to reduce both noise and emissions relative to the current state-of-the-art. The design for a geared turbofan engine was completed. Testing of a model fan in the Glenn Research Center 9X15 wind tunnel started in September 2006.

Rotary Wing Project

- Conducted helicopter flight tests to provide data for validation and improvement of rotorcraft acoustic analysis tools and to develop low noise flight profiles. The test was jointly executed by NASA, the U.S. Army, the Center for Rotorcraft Innovation, Bell Helicopter, and the University of Maryland. Test results will be used to test advanced prediction models.

Supersonics Project

- Under an interagency agreement with the Federal Aviation Administration (FAA), the Supersonics Project began a study of material and structural concepts for advanced fan containment systems applicable to both subsonic and supersonic aircraft. Initial material procurement and test article manufacturing is underway with testing to be completed during 2007.
- Working with the FAA, NASA expanded the understanding of supersonic boom noise and our knowledge of how to reduce it. An initial study of the impact of atmospheric turbulence on very low noise sonic boom waveforms was also completed. NASA F-18 aircraft, flying a specially designed flight profile, were used to generate the booms. Indoor and outdoor waveform shapes, noise levels and building vibration data were recorded for use in model validation studies.

Hypersonics Project

- Pushed the "high end" of the flight envelope jointly with the Air Force, through the Mach 5 ground testing of a thermally-stable advanced hydrocarbon fueled scramjet. NASA teamed with the Air Force Research Laboratory and Pratt & Whitney Rocketdyne to complete the tests on the Ground Demonstration Engine - 2 in the NASA 8-Foot High Temperature Tunnel. The NASA tests marked the first time a hydrocarbon-fueled, fuel-cooled scramjet with full-authority digital engine control was tested at hypersonic conditions.
- The Preliminary Design Review for the Hypersonic Boundary Layer Transition Flight Experiment (Hy-BoLT) was completed. This NASA/ATK flight test will acquire data for the effects of protuberances and cavities on aerodynamic heating that will be of value to the Space Shuttle. The Hy-BoLT experiment will be launched atop the ATK ALV-X1 launch vehicle from the NASA Wallops Flight Facility in mid 2007.

Partnerships

(Some of these partnerships are still under discussion)

Fixed Wing Project

- **AFRL/Boeing/NASA Blended Wing Body.** Purpose: Flight and ground validation of low noise/improved performance aircraft configuration; system level integration & validation, acoustics, aerodynamics, controls & dynamics, materials & structures, experimental capabilities, physics-based multi-disciplinary analysis & optimization (PB-MDAO); flight research with X-48B.
- **Boeing / Quiet Technology Demonstrators 3 & 4.** Purpose: Flight testing of low noise / improved performance technologies; acoustics, aerodynamics, aerothermodynamics, combustion, controls and dynamics; future test bed for other discipline studies (e.g. alternative fuels).
- **P&W / NASA Ultra-High Bypass Engine Research.** Purpose: testing of Ultra-High Bypass Engine technology for low emissions, low noise, and improved performance; combustion, aerothermodynamics, materials & structures, controls & dynamics; wind tunnel tests; static engine and flight operability tests with P&W 747 test bed aircraft.

Rotary Wing Project

- **NASA/Center for Rotorcraft Innovation (CRI).** Purpose: On-going discussions of potential collaboration in a variety of rotorcraft-related areas including but not limited to 1) Joint NASA/Army/CRI/Bell Helicopter Flight Test for Acoustic Prediction Development and Low Noise Flight Profile Development, and 2) Active Rotor Control. CRI has requested an interaction with NASA to explore the possibilities of flight testing an active control rotor.
- **NASA/Helowerks, Inc.** Purpose: To provide technical expertise and computational modeling of a Helowerks landing gear system. Helowerks will provide test specimens and hardware to be used at the vertical drop facility.
- **NASA/Army/Sikorsky/ZFL.** Purpose: Full-Scale Individual Blade Control (IBC) Wind Tunnel Investigation.

Supersonics Project

- **NASA/Gulfstream Aerospace.** Purpose: Supersonic Inlet Concept Evaluation. Active Flow Control for Mechanically Simple Axisymmetric Supersonic Inlets. Series of tests planned to develop a mechanically simple, non-bleed, external compression inlet to operate up to Mach 2.
- **NASA/Lockheed Martin.** Purpose: Slender Aircraft Aeroelastics. Application of non-linear, high-fidelity analysis tools to the evaluation of the interaction of aeroelastic behavior with basic flight stability and control.
- **NASA/AFRL.** Purpose: Supersonic Tailless Control Effectors. Analytical study of innovative control devices for tailless supersonic aircraft configurations.

Hypersonics Project

- **NASA/ATK.** Purpose: Hypersonic Boundary Layer Transition Flight Experiment (Hy-BoLT). Natural transition data (upper surface) and Shuttle protuberance impact on transition (lower surface) will be measured. The upper surface flow physics experiment supports hypersonic code testing. The lower surface measurements are in support of testing of hypersonics engineering tools for shuttle Return-to-Flight.
- **NASA/Aerojet/AFRL.** Purpose: Aerojet 3D Inlet: Test of inlet in the Unitary Plan Supersonic Wind Tunnel and CFD analysis on Aerojet vehicle-integrated 3D inlet design.
- **NASA/AFRL/DARPA.** Purpose: The X-51A project. This project will flight test a hydrocarbon fueled, airframe-integrated 2D scramjet for five minutes. The vehicle will accelerate under scramjet power from Mach 4.5 to 6.5.

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AVIATION SAFETY PROGRAM

Through the vigilance of industry and government, the U.S. Air Transportation System is widely recognized as among the safest in the world. Looking at the projected increases in air traffic and future system capabilities, this vigilance must continue in order for the U.S. to meet both the public expectations for safety and the full realization of the Next Generation Air Transportation System (NGATS). To meet these challenges, the Aviation Safety Program will focus on developing cutting-edge technologies to improve the intrinsic safety attributes of current and future aircraft that will operate in the global NGATS. Furthermore, these technologies can be leveraged to support space exploration activities, in particular to enable the self-reliant and intelligent systems necessary for the long-duration travel requirements of future space vehicles. The Aviation Safety Program is comprised of the following four projects:

Integrated Vehicle Health Management (IVHM): This project will conduct research to advance the state of highly integrated and complex flight-critical health management technologies and systems. These technologies will enable nearly continuous on-board situational awareness of the vehicle health state for use by the flight crew, ground crew, and maintenance depot. Improved safety and reliability will be achieved by onboard systems capable of performing self-diagnostics and self-correcting of anomalies that could otherwise go unattended until a critical failure occurs.

Integrated Intelligent Flight Deck (IIFD): This project will pursue flight deck related technologies that ensure crew workload and situation awareness are both safely optimized and adapted to the future operational environment as envisioned by the NGATS. A key component of this research will be investigating methods to automatically monitor, measure, and assess the state of the crew awareness to their assigned task. Project results should enable system designers to eliminate the safety risk of unintended consequences when introducing new and advanced systems into an operational environment.

Integrated Resilient Aircraft Control (IRAC): This project will conduct research to advance the state of aircraft flight control automation and autonomy in order to prevent loss-of-control in flight. Taking into account the advanced automation and autonomy capabilities as envisioned by NGATS, the research will pursue methodologies to enable an aircraft to automatically detect, mitigate, and safely recover from an off-nominal condition that could lead to a loss of control.

Aircraft Aging and Durability (AAD): This project will develop advanced diagnostic and prognostic capabilities for detection and mitigation of aging-related hazards. The research and technologies to be pursued will decrease the susceptibility of current and next generation aircraft and onboard systems to pre-mature deterioration, thus greatly improving vehicle safety and mission success. The intent is to take a proactive approach to identifying aging-related hazards before they become critical, and to develop technology and processes to incorporate durability and aging mitigation into the design of future aircraft. Foundational research in aging science will ultimately yield Multidisciplinary Analysis and Optimization capabilities that will enable system-level integrated methods for detection, prediction, and mitigation/management of aging-related hazards for future civilian and military aircraft.

A Few of the Aviation Safety Program's Recent Accomplishments

Integrated Vehicle Health Management Project

The IVHM project has made key advances in sensor technologies, analytical tools, and construction of simulation and test-bed capabilities, to include improvements to the Icing Research Tunnel at the Glenn Research Center and the upgrade of a Viking S-3 aircraft. The S-3 swept wing design and greater performance envelope make this an important testbed for characterizing commercial transport environments (relevant for engine icing issues.) Structural anomaly detection methods were also developed and demonstrated using laboratory fatigue-cycle data from lap-splice panels instrumented with the NASA-developed Fiber Optic Strain System (FOSS).

Integrated Intelligent Flight Deck Project

The IIFD project made major advancements in data mining for information sharing, new crew-vehicle interfaces for managing workload and maintaining situational awareness, and assessments of forward looking sensor technologies for hazard detection. Activities include research in support of a joint government/industry Information Sharing Initiative (ISI) that developed tools for data archiving and retrieval. Recent research also includes an assessment of head-worn display media for safe and efficient surface operations in low-visibility conditions, and multiple studies addressing the optimal fusion of synthetic and enhanced vision system display concepts.

Integrated Resilient Aircraft Control Project

The IRAC project developed a new test capability for simulating upset flight conditions and a refined ability to characterize the in-flight effect of vehicle damage. The Airborne Subscale Transport Aircraft Research (AirSTAR) testbed was completed and will support research in upset modeling, and prevention and recovery of transport category aircraft. Preliminary structural damage computational models were also developed for a transport airframe under discrete source damage.

Aircraft Aging and Durability Project

The AAD project advanced methods for predicting crack growth and the use of advanced composites for engine fan blade failure containment. A multi-scale analysis methodology was developed to model damage processes. This work is critical to both developing better criteria for crack growth propagation and designing more damage tolerant and durable structural materials. Proof of concept demonstrations for an improved lightweight composite engine casing capable of fan blade failure containment was also completed through a synergistic partnership among small businesses, aircraft engine manufacturers, and universities.

Partnerships

(Some of these partnerships are still under discussion)

Current collaborative partnership efforts include:

- Development of high-temperature thin-film ceramic strain gauges to measure static strain characteristics of engine components at high temperatures (Air Force Research Lab [AFRL]).
- Development of meteorological instrumentation for automated landing capability (AFRL).
- Icing cloud instrumentation (NASA, Federal Aviation Administration [FAA], National Research Council, Canada, Meteorological Service of Canada [MSC]).
- Icing environment remote systems development (NASA, National Oceanic and Atmospheric Administration, FAA, Transport Canada, and MSC)

We also anticipate several new activities with industry that will be conducted under new Space Act Agreements. Potential partnerships include:

- General Electric Aircraft Engines for disk materials microstructural behavior and modeling; engine fan containment structure durability, and hot-section sensors and methods for measuring turbine temperatures.
- Williams International for superalloy disk durability and engine fan containment structure durability.
- Boeing Commercial Aircraft for progressive damage modeling of composites; durability of bonded joints; durability and damage tolerance of composite fuselage structures and damage containment in integrally-stiffened metallic structures.

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AIRSPACE SYSTEMS PROGRAM

The Airspace Systems Program (ASP) conducts cutting-edge research that will enable the Next Generation Air Transportation System (NGATS). In partnership with the Joint Planning and Development Office (JPDO), the ASP will help develop the concepts, capabilities and technologies that will lead to the significant enhancements in capacity, efficiency and flexibility needed to meet the Nation's airspace and airportal requirements for decades to come.

The Airspace Systems Program will focus on two major projects: NGATS Air Transportation Management (ATM) Airspace and NGATS ATM Airportal. Fundamental capabilities developed in one project will be leveraged for the benefit of the other to make efficient use of available resources. Outcomes from each project will be integrated for gate-to-gate solutions.

NGATS ATM-Airspace: This project will develop and explore fundamental concepts and integrated solutions that address the optimal use of ground and air automation technologies necessary for the NGATS. Research in this project will address Four-Dimensional Trajectory Operations including advances in the science and applications of multi-aircraft trajectory optimization that solves the demand/capacity imbalance problem and manages the separation assurance requirement. Researching Traffic Flow Management and Dynamic Airspace Configuration will enable more efficient use of airspace by addressing the technical challenges of migrating from the current structured, static homogenous airspace to a dynamic, heterogeneous airspace that adapts to changing constraints of users' preferences, weather, traffic congestion, and a highly diverse aircraft fleet. Ultimately, the roles and responsibilities of humans and automation touch every technical area and will be addressed thoroughly.

NGATS ATM-Airportal: This project will develop and validate algorithms, concepts, and technologies for use in enabling integrated solutions designed to safely increase capacity and efficiency in the airportal component of the air transportation system. Currently, the growth of air traffic demand and fleet diversity is causing the operational volume at hub airports to rapidly approach their maximum capacity. Research will develop solutions that safely integrate surface and terminal area air traffic optimization tools and systems with Four-D Trajectory Operations. These tools and systems will be aimed at mitigating the growing constraints at the nation's hubs (e.g., adverse weather and wake vortex hazards) to enable significant increases in airport throughput.

A Few of the Airspace System Program's Recent Accomplishments

The Future Air Traffic Management Concepts Evaluation Tool (FACET)

- FACET, a flexible software tool that models the National Airspace System, won NASA's Software of the Year for 2006 award. Its powerful simulation capabilities can rapidly generate thousands of aircraft trajectories to enable efficient planning of traffic flows at the national level.
- FACET has successfully transitioned from the NASA laboratory to national operational use.

The Virtual Airspace Modeling and Simulation (VAMS) Project

- Completed operational concept development. VAMS provides a detailed description of a future capacity enhancing concept for the National Airspace System and an assessment of its potential capacity benefits.
- The System-wide Concept assessment was performed using the VAMS-developed Airspace Concepts Evaluation System (ACES) assessment tool. ACES models gate-to-gate operations of the NAS. Using ACES, VAMS demonstrated that the VAMS System-wide Concept could accommodate the targeted 2X increase in capacity (relative to 1997 throughput).

Industry Outreach

- ASP conducted an Industry Outreach workshop June 14-15, 2006. Included among the participants were Boeing, Cessna, Honeywell, Lockheed Martin, Rockwell Collins and United Airlines.
- Objectives included sharing project material with potential industry partners; allowing industry representatives to share and expound on their RFI responses from January; and identifying appropriate areas of collaboration.

Partnerships

(Some of these partnerships are still under discussion)

Airspace System Program is working on several Space Act Agreements to include:

- Working with Lockheed Martin on Inter-operable Air Traffic Management (ATM) trajectories, and the Tactical Separation-Assisted Flight Environment (TSAFE) for the En Route Automation Modernization (ERAM) system.
- Working with Boeing to clarify requirements for the Tailored Arrival Research in Separation Assurance.
- Working with Raytheon for the use of ASTOR software in a Net/Centric JPDO Demonstration.
- Exploring how the UPS/FAA merging and spacing field evaluations can contribute to NASA data in Airspace Super Density. UPS/FAA needs help in researching the end state of heterogeneous highly automated airspace.

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AERONAUTICS TEST PROGRAM

To ensure that NASA sustains its strategically important aeronautics ground test capabilities, the agency has implemented the Aeronautics Test Program (ATP) under the Shared Capability Asset Program. The goals of the ATP are to:

- Provide corporate management of the aeronautical test facilities that are considered to be national assets
- Increase the probability of having the right facilities in place at the right time for future usage by NASA, the DOD, other government agencies, and the U.S aerospace industry and academic community
- Operate these facilities effectively and efficiently in order to maximize user value
- Ensure intelligent divestment of duplicative and/or unneeded capability while making sound and strategic investments in those facilities that NASA is committed to sustaining.

As a specific example of how ATP supports the agency and the nation, we note that the implementation of NASA's Vision for Space Exploration will require the development of the Crew Exploration Vehicle, the Crew Launch Vehicle, and the Cargo Launch Vehicle. These development projects will require many hours of wind tunnel testing in the future across the speed range from subsonic to hypersonic. The ATP will ensure availability of the required wind tunnel testing capabilities to support the timely development of these vehicles without unduly burdening the Exploration Systems program with sustaining these test facilities in the interim.

The ATP has been structured to provide strategic management of the aeronautics ground test facilities at NASA's Ames, Glenn and Langley Research Centers. The four major elements of the ATP are:

- Operations support that provides funding for 60-75 percent of the fixed costs of a critical set of wind tunnels and air breathing propulsion test facilities to establish stable pricing commensurate with comparable domestic and foreign test facilities

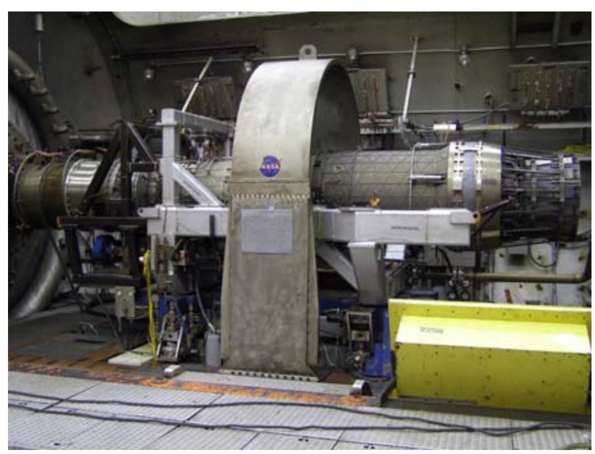
- Investments to support major non-routine maintenance projects to ensure long-term facility health
- Investments to support both the development and implementation of new test technologies; and
- Support for research in aeronautical facilities at the university level to train future researchers in the area of experimental fluid mechanics and aerodynamics.

Aeronautics Test Program's Recent Accomplishments

By implementing the ATP, NASA is sustaining the suite of ground testing capabilities that are critical to the Nation's future aeronautics testing needs. This is the ATP's principle accomplishment. Previously, the NASA Research Centers had the sole responsibility for the operations and maintenance of wind tunnels and air-breathing engine test cells without management oversight or direct financial assistance from NASA Headquarters. With decreasing use of ground test facilities came the inability of the Centers to sustain these valuable national assets. A notable example was the closure of the National Full-Scale Aerodynamics Complex by the NASA Ames Research Center. This event served as an alarm that prompt action was needed to ensure that additional unique facilities did not meet a similar fate.

Other specific accomplishments of the ATP in FY06 include exceeding the projected utilization of ATP ground test facilities, reducing the backlog of overdue maintenance activities in the ATP facilities, initiating test technology investments including standardizing wind tunnel measurement systems across all NASA Research Centers and developing test facility control system simulators, which allow facility engineers to simulate test operations for purposes of facility check-out and operator training.

Partnerships



A new National Partnership for Aeronautics Testing (NPAT) is being developed between NASA and the Department of Defense (DoD) to provide a national approach to test facility management. Plans call for engaging the aerospace industry as a partner in NPAT. The ATP management structure enables NASA to work effectively with DoD and industry to implement this partnership. The recently released National Research Council's Decadal Survey of Civil Aeronautics calls on NASA to "maintain state-of-the art testing capabilities" in order for NASA to be a leader in cutting-edge aeronautics research. This recommendation aligns well with ATP goals and objectives and further strengthens the case for having in place the strong and centralized corporate management provided via the ATP.